Chapter 10

Chesapeake Forest Monitoring Plan

1. Introduction

The primary goal of the Chesapeake Forest Project is to demonstrate that public forests can be sustained on an economic and environmental basis. Sustainability includes no soil deterioration or nutrient loss, no decline in water quality from activities, no loss or decline of species, the protection of special areas, an acceptable flow of jobs and revenue, and stakeholder satisfaction with results.

Monitoring is crucial to the success of the Chesapeake Forest (CF) Project, and, at a minimum, must meet requirements for certification and reporting. Monitoring is necessary to document sustainable practices, provide information to adapt management, and carry out elements required for certification as a sustainable forest by the Sustainable Forestry Initiative (SFI) and Forest Stewardship Council (FSC). The FSC specifically identifies monitoring and assessment as one of its ten Principles, and monitoring data are needed to meet a number of SFI Core Indicators. Evaluation of the range of elements being sustained relies on an interdisciplinary plan that monitors a wide range of aquatic and terrestrial features. A monitoring project on this scale provides opportunities for scientific study, collaboration, and external funding. It also provides challenges, such as the need for an efficient, coordinating structure for the monitoring program and limits to the involvement of current staff in the project. This critical component of the Chesapeake Forest Project will not be successful unless support continues to be adequate, whether financed by CF income or other sources.

2. Monitoring Plan

The monitoring plan supports the needs of the Chesapeake Forest Project using a multi-tiered approach:

- Tier I: a landscape-scale inventory
- Tier II: a stand/complex-level inventory, and
- Tier III: project-specific assessment and research.

In order to more efficiently use resources, data collection is coordinated as much as possible among the different units' staff. The exact number of points to be sampled will depend on the number of points falling within multiple strata, and potentially on the cost/effort for sampling. Power analysis and community dynamics models will be used to help determine the appropriate number of samples to allow trends in population changes to be detected. At the beginning of each section, the SFI Objectives and FSC Principles that are addressed by these elements of the monitoring plan are listed, with text descriptions supplied in Appendix A.

Data obtained from the monitoring has been used to update the Chesapeake Forest Geographic Information System, and spatially integrated with the base ownership layer. Data collected in Tier I inventory included GPS coordinates, which are kept for references to the 210 permanent plots. DNR units and personnel have been assigned to manage the layers of information based on data source and unit expertise, including Forest Service, Heritage, Resource Planning, Monitoring and Non-Tidal Assessment, and contacts for the Technology

Toolbox and Property View. New data are added to the GIS system through the data manager assigned for the respective layers.

Tier I: Landscape-scale, Long-term Monitoring

Objectives:

The focus of Tier I monitoring is overall biodiversity and ecosystem health. It provides the basic inventory data for forest management, sensitive resources, and water quality over physiographic and hydrogeomorphic regions. Tier I monitoring provides the information base for Sustainable Forestry Initiative certification Objectives 1, 3, 4, 5, and 6, and for Forest Stewardship Council certification Principles 5, 6, 7, 8, 9, 10 (Objectives and Principles listed in Appendix A). The first round of data collection was conducted in 2004, including:

1) Forest overstory condition, including stand inventory, tree growth rates, and regeneration status, yielding information needed to determine sustainable levels of harvesting;
2) Forest understory condition, including height of canopy layers, species, diversity, and presence of invasive species;
3) Wildlife and habitat information, including bird, reptile, and amphibian species, diversity, relation to habitat features like snags, woody debris, stand size class, percent canopy, vertical diversity, and suitability for endangered Delmarva Fox Squirrel habitat; and
4) Water quality surveys of nutrient status, macroinvertebrate populations, and aquatic habitat condition that supplement the Maryland Biological Stream Survey data, supplying water quality status and aquatic invertebrate species presence and diversity.

The inventory sampling approach assured representation of sensitive resource areas like forest interior habitat, Delmarva fox squirrel habitat, ecologically significant areas, and riparian areas. Special area boundaries including sensitive species protection and restoration areas and cultural resources such as ruins, graveyards, research plots, or wells have been added to the GIS system as encountered or sought out. Inventories are scheduled for update every 5 years.

The definition of sustainability given above for the publicly owned Chesapeake Forest included stakeholder satisfaction with results. Existing processes, including public meetings on annual work plans, interdisciplinary team for management review, and the Citizens Advisory Committee, all provide outlets for expression of stakeholder views. Information is provided on the DNR website, http://www.dnr.state.md.us/forests/chesapeakeforests/, including the sustainable management plan and annual workplans. These information sources will be used at a minimum to estimate stakeholder satisfaction. Independent survey of known stakeholders may be undertaken if outside funding and partners are secured.

Methods Overview:

Strata for sampling were chosen for major factors of interest and to control for known variation. Stream and water quality sampling are organized around geomorphic region and the stream network, while terrestrial sampling uses strata based on forest type and habitat for sensitive resources (Table 20). Geomorphic regions split out areas based on underlying geology

and topographic characteristics, which usually control major differences in stream chemistry (e.g., acid or alkaline, base levels of nutrients). The stream network is stratified on position relative to CF ownership, and will correspond partially to stream order; streams originating entirely in CF land are likely to be smaller (first, second, or third order), while streams passing through or bordering CF lands are likely to be larger (third order or higher). Terrestrial strata focus on major stand types and areas with rare species, most of which are already defined and available in digital form, since these two criteria have the greatest effect on management actions undertaken. The information base for the sampling is the Chesapeake Forest GIS system, managed out of the Chesapeake Forest Office at the Wicomico Demonstration Forest.

Table 20: Strata Identified for Long-term Monitoring in the Chesapeake Forest, Maryland

Stream and Water Quality Sampling		**Terrestrial Vegetation and Species Sampling**	
Geomorphic Region	***Stream Location***	***Forest Composition***	***Sensitive Resources***
Surficial Confined	Originates in Chesapeake Forest	Pine	Forest Interior Dwelling Species (FIDS) Core
Fine-grained Lowland	Passes through CF	Upland Hardwood	Delmarva Fox Squirrel (Core and Future Core)
Well-drained Upland	Borders CF	Bottomland Hardwood	Ecologically Significant Areas
Poorly Drained Upland		Mixed Pine-Hardwood	Riparian/Wetland Areas
Poorly Drained Lowland			

Terrestrial Vegetation and Species Sampling

For terrestrial samples, approximately 1000 12-acre plots were defined using a randomly-placed GIS Hexmapper grid that covers the entire Chesapeake Forest area with equal-area plots. A total of 210 plots were randomly sampled from the 1000 potential plots, using the center point of the 12-acre hex to locate sample plots unless it did not lie within the CF boundary. To gather detailed data on bird and amphibian abundance and habitat features, a subset of 82 plots from sensitive resource plots were selected for additional data collection using multiple visits from spring to late summer to adequately sample seasonally available populations. All permanent sample points are expected to be sampled at least once every 5 years. In order to ensure that there are adequate samples to examine trends in the data, a minimum of 20 plots were assured for the less common strata like Ecologically Significant Areas.

Vegetation structure and composition were quantified using methods similar to those of the Continuous Forest Inventory, based on USDA Forest Service inventory sampling and analysis methods. In addition, percent ground cover, canopy cover, vertical layer presence and height, tree regeneration, coarse woody debris, depth of organic layer, forest health indicators, and data for invasive species, shrubs, and herbaceous plants were collected. Data analysis was contracted with USDA Forest Service Forest Inventory and Analysis section and used techniques consistent with the Maryland forest inventory. Data summaries for forest overstory include tree volume, basal area, density, and growth rates. Calculations for wildlife information include the

Shannon-Weiner diversity index, relative frequency, and relative abundance. Analysis of Variance is used to determine contribution of stand types and age classes to observed population characteristics. Vegetation information from the detailed wildlife habitat subset of plots was analyzed using detrended correspondence analysis techniques to identify six community types.

Living organisms were monitored with emphasis on sensitive species, including forest interior dwelling and other birds, reptiles, and amphibians. Standard methods included constrained time searches, pitfall traps, and call counts, tailored to the species' habits.

Stream and Water Quality Sampling, Procedures, and Progress

For aquatic samples, points are chosen using stratified random sampling from mapped ("blue-line") stream sections that are 150 m in length. Streams must traverse a minimum of 1000 feet on a CF parcel. These stream sampling points are re-randomized for each sampling event (at least every 5 years) in order to more accurately capture the general condition of the aquatic resources. Baseline water quality was sampled in 2002, emphasizing areas in forest interior-dwelling bird habitat.

Water quality monitoring used procedures outlined in Boward and Friedman (2000). Water samples are collected during baseflow at all sites with water, standing or free flowing in a defined channel, avoiding the 24-hour period following a minimum of 0.5" of rain. Sampling includes flow (L/s), water temperature (^{o}C), dissolved oxygen (mg/L), pH, and conductivity measurements at each site using field instruments (e.g., Hydrolab Surveyor II). Grab samples of whole water are collected just below the water surface at mid-stream and filtered in the field (0.45: pore size Gelman GF/C filter). To allow for analysis of nitrogen species, the samples are stored on ice and frozen the day of collection for later lab analysis. Analysis includes dissolved inorganic nitrogen (mg N/L of NO^3, NO^2, NH^4) and dissolved inorganic phosphorus (mg P/L PO^4). All analyses are conducted in accordance with US EPA protocols.

Aquatic benthic macroinvertebrates are collected using methods developed for mid-Atlantic coastal plain streams that are compatible with and comparable to Maryland Biological Stream Survey (MBSS) sampling protocols (Kayzak, 2001). Samples are collected only from free-flowing streams, avoiding inaccuracies associated with evaluating standing pools. Sample processing is done according to MBSS guidelines (Boward and Friedman, 2000). Habitat assessments based on US EPA methods for low gradient streams (Barbour et al., 1999) are completed at all macroinvertebrate stations. Summary measures include the Benthic Macroinvertebrate Index of Biotic Integrity, Habitat score, and percent of suitable habitat.

In 2002, 82 stream segments were randomly selected for sampling. Many segments were dry, given the extremely low rainfall and groundwater levels during most of 2002, and a few other segments had no reasonable access, leaving 33 sampleable sites for grab samples. Some sites had no measurable flow, so were not evaluated for macroinvertebrates. Almost all sites meet the hypothesis that water quality measures do not exceed desirable standards (Table 21), and the sampling helps identify areas and characteristics of sites most appropriate for improvement of water quality or habitat.

Table 21: Synoptic Water Quality sampling on Chesapeake Forest Lands, Spring 2002

Measure	*Range*	*Average*	*Comment*
PO4, mg P/L	0.001 to 0.160		
$NO_{,3}$, mg N/L	0.01 to 12.00		Only 1 site over 10 mg/L standard
Temperature (^{o}C)	3.75 to 14.48		
pH	5.20 to 8.21		Acceptable range (not sure of source of high pH)
Conductivity	0.046 to 0.259		
Dissolved Oxygen (mg/L)	4.63 to 12.10		All within acceptable limits
Discharge (L/s)	0.000 to 110.646		0 discharge indicates stagnant water
Habitat Score	60 to 129		140-112 Excellent, 105-77 Good 70-42 Fair, <35 Poor
Habitat %	43 to 95		>80% Excellent, >55% Good, >30% Fair, <25% Poor
Index of Biotic Integrity	1.86 to 3.86		Highest rating is only fair.

Tier II: Stand/Complex-level Medium-term Monitoring

Objectives:

This level of monitoring is used to give more specific information on:

1) Occurrence and management needs for rare, threatened, or endangered species,
2) Areas where invasive species threaten populations of rare species,
3) Stands or complexes where more information is needed to support high production of wood fiber or other marketable product, or
4) Other species or areas of interest that occurs across several stands.

Emphasis will be placed on sites that need to be protected, enhanced, or restored to maintain healthy native communities. Factors assessed at this scale include water quality and sensitive resources, including species presence, richness, and diversity. In areas identified for high production of wood fiber or other marketable forest products, more frequent and more intensive forest stand data may be needed to inform management options. These monitoring activities will occur more frequently and in focused areas compared to Tier I monitoring. Tier II monitoring supplies information needed to carry out or document SFI Objectives 1, 3, 4, 6, and 8, and FSC Principles 5, 6, 7, 8, 9, 10.

Methods Overview:

Sample points for sensitive resources will be selected using random sampling or, when necessary, stratified random sampling. Cluster sampling may be used for rare plants. For forest stand condition, systematic grid sampling will be used for greatest efficiency, avoiding lining up the grid with obvious landscape patterns (streams or ridges) to preclude bias in sampling. Data collection will occur more frequently than in Tier I monitoring, with the timing dependent on the organisms/habitat features to be monitored. This monitoring may be ongoing or of limited duration.

Standard methods available in federal or state manuals or published peer-reviewed research will be used to collect data for:

- Water quality indicators such as stream nutrient export, wetland condition, fish and aquatic macroinvertebrate assemblages;
- Forest stand condition indicators such as vegetation structure and composition, invasive species, natural plant communities, insect and disease impacts, fuel loading, and stand density;
- Rare, threatened, and endangered species presence, diversity, and abundance; and
- Presence of invasive species that threaten the survival of rare, threatened, or endangered species;
- Other indicator species.

Trail impacts can be monitored in specific areas of concern using standard limits of acceptable change (LAC) procedures (Stankey et al., 1985; McCool and Cole, 1998) and procedures developed specifically to assess trail impacts (Marion and Leung, 2001). Methods to monitor populations of rare, threatened, and endangered species in Ecologically Significant Areas will depend on the organisms of interest. Protocols will generally follow standardized methods presented in Tier I. Power analyses will be used to help determine the appropriate number of samples to allow a trend to be detected. Unique natural communities will be monitored using standard plot methods for community classification. Forest stand information may include data for stand-level growth and yield modeling, soil sampling, and overstory and understory composition.

Invasive Species:

Information on general occurrence of invasive plants is captured in the Tier I inventory, and will be updated on the same cycle as that inventory. The baseline inventory found common invasive species on Chesapeake Forest on a third of the plots in wetlands, stream buffers, and Endangered Species Areas. The most ubiquitous invasive was Japanese honeysuckle (*Lonicera japonica*). Other common invasives were Japanese stiltgrass (*Microstegium vimineum*), phragmites (Phragmites australis), mile-a-minute (*Polygonum perfoliatum*), and multiflora rose (*Rosa multiflora*). More intensive monitoring and control will be targeted to those areas where they might compromise the health and survival of rare, threatened, or endangered species. Invasive species control plans will be developed in conjunction with rare species protection and restoration plans. Control plans will include actions to prevent or minimize reinfestation of problem species, such as when management operations are in adjacent areas. Control options will be tailored to the situation and species, and may include physical, chemical, or biological controls.

Problematic invasive species are sometimes identified in routine field operations, outside of rare species habitat. In these cases, staff will determine the potential to interfere with the survival, health, or regeneration of native forest stands. Where the invasive species is a significant detriment, a management strategy for control will be developed and included in the annual work plan review. Chemical control is anticipated in many settings because of the general effectiveness and cost-efficiency, although any effective option including physical or biological control will be considered. Species that have potential to interfere greatly with forest health and regeneration include multi-flora rose, mile-a-minute, and Japanese wisteria.

Tier III: Management Activity-based Short-term Monitoring

Objectives:

Monitoring at the Tier III level measures responses to management activities at a finer scale, including silvicultural treatments, restoration projects, and public uses that may affect a portion of a stand or the whole stand. This level of monitoring includes updates of stand-level information to reflect recent management actions and some focused scientific studies, with monitoring occurring on both control and experimental areas before and after the manipulation. Measurement and monitoring of soil quality, water quality, and species presence, richness, and diversity allow us to monitor these indicators of sustainability from the Sustainable Forest Management Plan for the Chesapeake Forest Project over the long term. Tier III monitoring is needed to document compliance with SFI Objectives 1, 2, 3, 4, and 6 and FSC Principles 5, 6, 7, 8, 9, and 10 (Appendix C).

Methods Overview:

Sample plots are chosen randomly or systematically within appropriate control (reference) and experimental areas (areas to be manipulated). Where possible, at least 3 replicates are sampled for each type, with more than one sample taken in each plot. Potential experimental area treatments include prescribed burns, herbicide applications, harvest systems and practices, watershed restoration and improvement projects, and ESA restoration activities. Measurements of stand health, biodiversity, productivity, soil fertility, water quality, and species-specific responses are most appropriate for this level of monitoring.

Procedures by Forest Management Actions:

Harvesting (For SFI Objectives 2, 3, 4, 5, 6):

All thinning and regeneration harvest operations are checked for compliance with Best Management Practices. Two forms are used as field checklists (2001 Master Logger checklist, and the Vision Forestry logger feedback form). Checklist items include water quality BMPs, safety BMPs, and forest stand/soil condition.

The harvest area selection process occurs through Interdisciplinary Team review, based on an Annual Work Plan recommended activity list generated by the forest manager. Stands are selected based on age, stocking levels and species composition. Consideration is given to size of the area to be harvested and its proximity to stands less than seven years of age. Currently, most silvicultural prescriptions are for commercial first and second thinnings. However, final harvests of young stands are anticipated in order to regulate an unbalanced forest condition based on age class distribution. Silvicultural prescriptions may be modified based on the following:

- Presence of rare species, including Delmarva Fox Squirrel Areas and Forest Interior Dwelling Species, Wetlands of Special State Concern, Threatened and Endangered species (state and federal) (existing database and some field checks);
- Stream/ditch buffers (later identified and flagged in the field);
- Cultural sites (e.g., graveyards, ruins);

- Presence or absence of advanced regeneration (i.e., whether suitable for natural regeneration, planting, or direct seeding).

Site Preparation

Natural regeneration is considered as the first option, so advanced regeneration is evaluated (plot counts to estimate seedlings/acre, with attention to distribution over harvest area). Site preparation methods considered by the Interdisciplinary Team for the Annual Work Plan review include but are not limited to prescribed burning, herbicide application, and mechanical treatment.

Prescribed Burning

Prescribed burning is recommended for site preparation or after thinning to control understory vegetation and encourage regeneration of native fire-adapted plants. Procedures for establishing the prescription for a burn include evaluating the site for fuel load, ability to carry a burn, locations of fire breaks, and potential hazards of smoke to surrounding locations (e.g., well-traveled roads, confined livestock, neighbors). Prescribed burn plans are prepared by MD DNR fire staff, using guidance from "A Guide to Prescribed Fire in Southern Forests" (1989, USDA FS National Wildfire Coordinating Group publication PMS 431-2). MD DNR fire personnel evaluate all sites after burning to determine if the burn met the stated objectives. MD DNR Heritage staff specialists evaluate selected sites with high potential for rare species for presence and abundance of target species following burn treatment.

Herbicide Application

The use of herbicides is being minimized on CF lands, but there are instances where their use is appropriate to effectively shape the stand to its desired condition for forest products and/or habitat with minimal impact to soils. Herbicides are applied according to label restrictions, with spray buffers around flowing streams or open water. Application is most commonly by air (helicopter), with backpack application used where spot spraying is the only need. Management on Chesapeake Forest in many areas seeks to establish a mixed stand that includes pine and hardwoods, particularly oak species valuable for rare species such as Delmarva Fox Squirrel and many other wildlife species. Oak species tend to be more resistant than other hardwoods such as sweetgum and red maple to a commonly used herbicide such as Arsenal AC at reduced rates. While gum and maple are native species, the lack of wildfire has allowed their density and frequency to greatly increase at the expense of other hardwoods, and they lack the mast that is a winter staple for wildlife.

Current projects are spray trials to determine the lowest herbicide rate to control most gum and maple while avoiding eradication of oak species. Vision Forestry set up a spray trial on the E. Mace Tract to compare effectiveness of 4 rates of Arsenal (7, 8, 10, and 12 oz/ac.) and a control non-spray area. Baseline data and treatment results will be evaluated after 2 growing seasons. Data collection focuses on vegetation: grasses, mature trees, saplings, seedlings, and shrub/herb layers. Good control of maple and sweetgum were achieved at all levels, although

followup data to determine effects of sprouting in later years is continuing. Based on the results of the trial, the standard rate of application of Arsenal following thinning has been reduced to 8 oz/acre.

The trials are designed to test whether there is change in proportion of hardwood to pine before and after the herbicide spray for each of the different rates. Measures to be tested include:

- proportion of hardwood to pine,
- percent oak and poplar, and
- percent maple/sweetgum.

Measured items include trees, saplings, and seedlings, with composite stems/acre being calculated as the sum, at each level of spray in comparison to the control area. Diameter and volume growth of pines under the different spray levels is also of interest.

The E. Mace Smith trial area is a recent thin, but results should be applicable to both thinning operations and regeneration harvests. Vision Forestry also has set up a trial on the Haislip Butler tract, stands 1 and 2 (1982 and 1991 plantations respectively), using a lower concentration of herbicide (8 oz./acre Arsenal), with no spray on windrows where hardwood concentrations are highest. This trial will be used to monitor development of oak, maple, and gum in the loblolly plantations and the ability of this type of prescription to develop a mixed pine-hardwood stand. Lower rates of herbicide were used in a trial on the Smullen tract because even the 7 oz. rate used earlier achieved more mortality of hardwoods than expected. However, the installed trials on the Smullen tract later suffered a wildfire that destroyed plot center markers and the ability to distinguish effects of different levels of herbicides.

Water quality was sampled for residual herbicides on October 5 and 15, 2003 from an October 3rd spray of Arsenal (active ingredient imazapyr) on the Smullen tract. Sampling was done at four locations in a waterway on the interior of the spray tract with a 150-foot buffer, spray rate of 5 oz/acre. No imazapyr was detected at the time of spraying or two weeks later, using a detection limit of 1 part per billion. The currently used procedures and spray buffers were successful in avoiding transport to water bodies, even one in the interior of the tract being sprayed.

Mechanical Treatment

Mechanical site preparation usually involves heavy equipment such as a bulldozer, which may be augmented by lighter equipment such as chain saws or brush saws. A drum chopper may be used to condense slash and allow the site to be burned and planted. If slash is too dense to permit regeneration or planting, root raking and piling is considered. Root raking may also be used in restoration efforts to remove invasive species from unique habitats (i.e. windrows in Carolina Bays). Riparian buffers are flagged in the field to assure that machinery does not affect water bodies and no delivery routes for sediment are established during the operation. Excessive rutting and soil compaction are avoided as required in Maryland Forest Harvesting BMPs, and are monitored through the use of the Harvest Site Review form.

Intermediate Operations

Commercial and pre-commercial thinnings are planned for the Chesapeake Forest. The same procedures as outlined for harvesting are followed, regarding site review, modification of operation for rare or sensitive species, and BMP compliance.

Fertilization during thinning operations is done only on phosphorus deficient soils, which is guided by a Nutrient Management Plan. Soil tests for N and P are conducted pre and post application to ensure the desired outcome. Only urea-based fertilizers are used. Fertilization does not occur within the 300-foot riparian buffers.

Chesapeake Forest is participating in a forest growth and yield study in cooperation with Virginia Polytechnic Institute and State University, with Dr. Ralph Amateis as principal investigator. Stand data was collected in January 2003, and information has been used in the growth and yield models (e.g., TAUYIELD, PCWTHIN, and ECONHDWD). Sampled stands were located on the Dail, Martino, and Osborne tracts in Dorchester County and the Baldy Pusey tract in Somerset County. This study investigated growth responses to different thinning regimes, to test the effect of individual tree growth increases on the per acre growth in basal area and volume.

Additional research related to thinning operations is in the planning stages in Vision Forestry to investigate effect on regeneration amount, species, and distribution. Data to be collected in sample plots include initial and residual basal area of overstory trees and number and species of woody seedlings. Heavier thins are expected to result in greater amounts of regeneration, especially for light-demanding species such as pine or oak. Hypothesis to test include:

H_0: There is no change in density of seedlings following thinning to varying basal areas.
H_A: There is a change in density of seedlings following thinning to varying basal areas.

Special Area Projects for Water Quality and Wildlife

Some additional projects are being undertaken for water quality and wildlife objectives. Watershed improvement projects are chosen in locations where slowing water could improve nutrient and sediment levels in water leaving Chesapeake Lands. Projects require at least two critical elements: 1) waterway and topography where water can be slowed and backed up to increase residence time without adversely affecting neighboring lands, and 2) source of nutrients or sediment, such as from agricultural lands (rates from forest lands are already low). Monitoring includes pre-project baseline information and post-project assessment of water quality and vegetation.

Current projects are taking place at five locations on the Chesapeake Forest. The primary DNR contacts are Kevin Smith for project coordination and John McCoy for water level monitoring, both with Watershed Services, Watershed Restoration Division.

1) The Jones Tract project in Worcester County proposes two berms to divert and retain overbank flow from a tax ditch (draining many other properties and land uses), restoring hydrology to a stand with bald cypress. Monitoring at this location is being done in

partnership with Salisbury State University, Vision Forestry, and MD DNR Watershed Services. It includes vegetation transects to evaluate changes in tree regeneration and understory plants, soil sampling for organic matter, N, P, redox status, and pH, and ground water levels to evaluate changes in hydrology. Water level monitoring showed very infrequent surface ponding until the record rainfalls of the fall 2003 and spring 2004, although surface ponding still lasted less than two weeks for the most part.

2) The Puckum Branch tract in Dorchester County was completed in 2004 and is being monitored using visual assessment protocols and photopoints by Maryland Department of the Environment. The project added biologs to improve stream habitat characteristics. Pre-construction sampling of fish and herpetologic species has been completed. Fish assemblages were dominated by American eel, eastern mudminnow, and creek chub sucker. The most common amphibians were southern leopard frog, bullfrog, and green frog.
3) The Morris Millwork tract (#7144) in Wicomico County has been surveyed, and the design is under development by Maryland State Highway Administration as of April 2005.
4) The Dunn Swamp tract (#3716) in Worcester County proposes small ditch plugs to create wetlands. The survey and design are complete as of April 2005, and construction is anticipated for the summer of 2005.
5) The Pepperfield tract is under design by the Maryland State Highway Administration as of April 2005. Baseline water quality sampling on the Rayfield Ditch, Pepperfield Tract, by Vision Forestry has included nitrogen (NO^3, NH^4, and NH^3), phosphorus (PO^4, ORP), pH, dissolved oxygen, conductivity and coliforms, and total suspended solids. Results revealed high levels of coliform bacteria and level of nitrate near or exceeding state water quality standards in the tax ditch. Simultaneous sampling in a smaller ditch draining primarily just the forested tract (from 3-35 years old) also showed high levels of coliform bacteria, but low levels of nitrate (order of magnitude or more lower).

Habitat Improvement Projects are chosen in areas with great potential to support rare species types. MD DNR Heritage Program is developing management plans for selected areas, and restoration projects will be implemented as part of the annual work plan. Projects include clearing trees in areas where rare species depend on more open conditions, and restoring hydrology where past drainage has reduced extent of wetland habitat. Presence and extent of rare species will be recorded before and after projects. Chesapeake Forest granted a use permit for University of Maryland Eastern Shore (primary contact Lori Lilly) to conduct research on the forest community structure and effects of disturbance on *Pinus echinata*-dominated dunes. This project will provide information that should improve ability to manage the dune areas to support these communities.

Chesapeake Forest lands are being surveyed annually for bird presence. Bird counts are added to other regional data and summarized in the Breeding Bird Atlas. A detailed study of bird use, including forest interior dwelling species, was completed previously by principal investigators at Frostburg University, and found extensive use even in some pine-dominated regions. Follow-up study of this result is anticipated in partnership with Frostburg or another university.

Public Use and Recreational Activity

Hunting is permitted on Chesapeake Forest lands, including public hunting and fee hunt clubs. For lands open to public hunting, monitoring consists of periodic roadside vehicle counts during hunting season. Club hunting is monitored using a database which tracks revenue, number of hunters per club per tract, maintenance the club has provided and an annual harvest report. The annual harvest report includes estimates for harvest by species: white-tailed deer, sika deer, turkey, dove, quail, squirrel and rabbit. Waterfowl hunting currently is not included in the hunt club agreements, although the reporting form makes provision for it.

Public use data will be collected via checklist surveys, permit applications, and other quantitative methods comparable to those used by the USDA Forest Service, US Fish and Wildlife National Refuge System, and Maryland DNR Wildlife Division.

Other recreational activities (such as trail use for horseback riding, birdwatching, or hiking) are monitored through use agreements outlining terms and conditions of use for organized for-profit groups. Ongoing survey efforts such as the national surveys for fishing and hunting and county recreational surveys will be used as additional information sources and for context to allow comparisons of patterns of use on Chesapeake Forest. Other methods such as online user forms and honor system use survey boxes will be used as time, resources, and departmental approval permit. As stated earlier, impacts to use areas may be monitored using limits of acceptable change (LAC) protocols, provided funding is available (Stankey et al., 1985; McCool and Cole, 1998). Chesapeake Forest cooperated in an effort to collect white-footed mice and black-legged ticks as part of a Lyme disease study by Johns Hopkins Bloomberg School of Public Health during 2003.